COMBINED SEWER SYSTEMS AND THE POTENTIAL FOR VECTOR-BORNE DISEASES IN GEORGIA

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Abstract. Combined sewer systems treat and dispose of water from combined waste and storm water sources. During times of heavy rainfall, minimally treated water is released into associated streams adding organically-polluted waters to the stream system. *Culex quinquefasciatus*, the primary West Nile virus vector in Georgia, thrives in organically-polluted waters. Surveillance data suggest that the presence of combined sewer systems should be considered a risk factor for West Nile virus infection in humans.

INTRODUCTION

The purpose of this paper is to present some background information about West Nile virus (WNv) in Georgia and to highlight some current research into the effect that combined sewer systems (CSS) have on human risk of WNv in metro Atlanta.

Many urban areas in the United States, particularly in the northeastern and central states, combine waste and storm water sources into a combined sewage system for treating and disposing of water. In this system during normal operating conditions, minimally treated wastewater and storm water are mixed and then piped to a waste water treatment facility. However, during times of heavy precipitation when the water volumes generated during storms exceed the capacity of the water treatment facilities, the combined waste and storm water is allowed to bypass the treatment facility to be discharged directly into streams or lakes after only minimal chlorine treatment and sieving to remove large physical contaminants. These combined sewage overflows (CSOs) or “events” result in the release of untreated human and industrial waste, toxic materials, and debris (EPA website).

West Nile virus (WNv) is maintained in a mosquito-bird transmission cycle. Humans, horses and other mammals are dead-end hosts unable to produce sufficient viremia to infect mosquitoes feeding on them. Enzootic maintenance of WNv is dependant on the juxtaposition of susceptible bird and vector populations and the presence of the virus. Transmission to mammals requires a bridge vector between bird and mammal populations in the form of a mosquito species that feeds willing on both birds and mammals. Although more than 60 mosquito species have tested positive for WNv, members of the *Culex pipiens* complex (*Cx. pipiens* and *Cx. quinquefasciatus*) and *Cx. tarsalis* are dominant species in the enzootic maintenance and amplification of this virus in the United States (Turell et al., 2005, Hayes et al., 2005). These species may also serve as bridge vectors to humans and other mammals. There are more than 700 CSS in the United States, and the effluent from these CSS creates potential breeding sites for *Culex* spp.

Field studies in the southeastern United States incriminated *Cx. quinquefasciatus* as the principal WNv vector in Florida (Rutledge *et al*., 2003), Georgia, and Louisiana (Godsey *et al*., 2005). *Culex quinquefasciatus* breeds in many different water sources, attaining high larval densities in water sources with high organic content such as sewage treatment ponds, drains, and pit latrines. Its flight range is generally thought to be ¼ to ½ mile from the emergence site.

West Nile virus tends to be a highly localized disease of urban areas. In Georgia, CSS have the potential to produce large numbers of *Cx. quinquefasciatus* depending on water flow patterns. Infrequent flooding could increase the risk of urban transmission of WNv within the flight range of *Cx. quinquefasciatus* by allowing rapid buildups in the vectors that breed in CSS streams. Within the metropolitan-Atlanta area of Georgia at least seven CSS facilities have been identified (Table 1). Several other CSS situations, without physical plants, also appear to exist. The CSS streams in Atlanta are centrally located in close proximity to residential, commercial and recreational areas (Figure 1). If streams receiving CSS effluent are used by *Cx. quinquefasciatus* for oviposition, the potential for WNv transmission in urban areas could be significantly increased. Combined sewage system streams, located as they are in green spaces throughout the metro Atlanta area, provide most of the necessary factors for WNv transmission: birds, mosquitoes, and human populations. All that is needed is the virus.

Table 1: Known Combined Sewer Systems in Atlanta

East Area CSS
Custer Avenue
Intrenchment Creek
McDaniel Street
West Area CSS
Clear Creek
Greensferry
North Avenue
Tanyard Creek

SURVEILLANCE

West Nile virus was first detected in Georgia in 2001, with 6 human cases reported, including one death. One of the reported cases, and the only death that year, lived in the city of Atlanta. Fulton County, which includes the city of Atlanta, has had 40 human cases of WNv reported since 2001, with 61% of the cases with known addresses living within one mile of a CSS or CSS stream. Six of the cases were homeless and it is unknown where they were living when they became infected with WNv; four others did not report mappable addresses. Based on surveillance data collected in Fulton County since 2001, positive mosquito pools are also more likely to be detected around CSS and CSS streams (Figure 1).

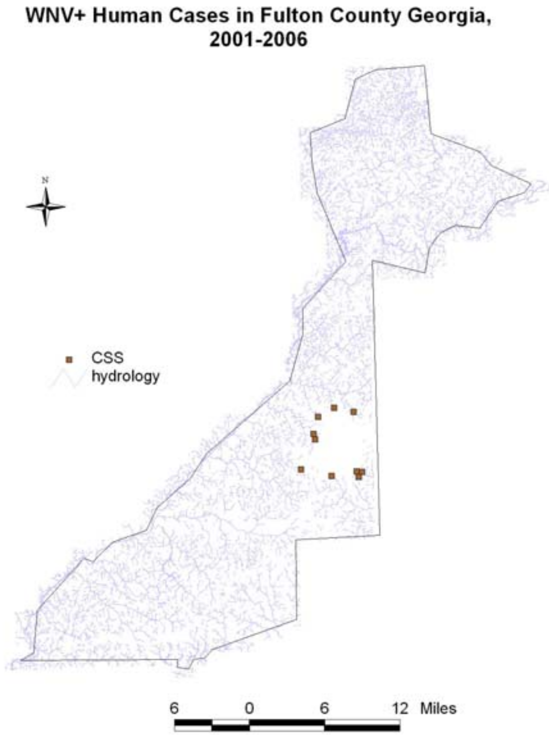
ONGOING RESEARCH

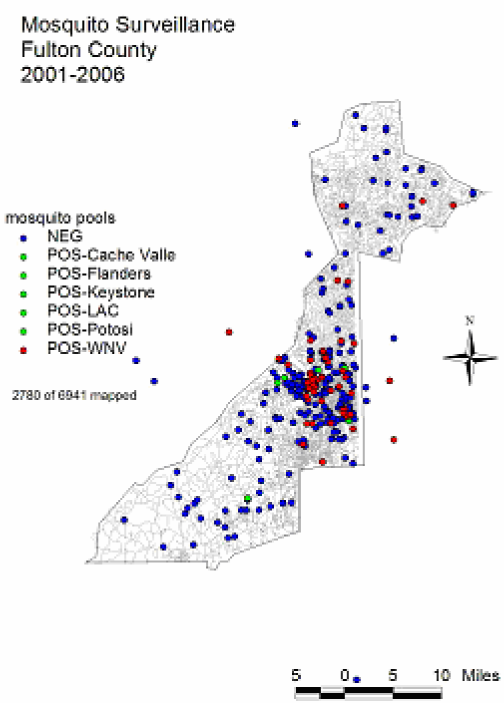
Study #1

Storm drain systems can sustain both larval and adult mosquito populations. Underground tunnels and pipes provide protection and a relatively stable microclimate for resting adults produced in drainage systems (Smith and Shisler 1981). Mosquitoes utilizing such environments have been determined to play a significant role in the vectoring of various arboviruses (Marfin et al 1993).

A longitudinal study of mosquito ecology in Tanyard Creek, an urban stream in Atlanta that receives waste water effluent from the Atlanta combined sewage system, was undertaken in 2005 by the Centers for Disease Control and Prevention in cooperation with the Fulton County Department of Health and Wellness and the Georgia

Figure 1: WNv Surveillance, Fulton County GA





Division of Public Health. The overall goal of this study was to define the role of CSS streams for WNv vector mosquito production in Atlanta. Specific objectives for this study of the CSS stream were (1) to identify the mosquito species utilizing the streams, (2) to determine the environmental factors associated with increased mosquito densities, and (3) to understand the primary factors that regulate mosquito populations in these streams.

Study #2

The type of infrastructure presented by Atlanta CSS facilities provides environmental conditions that facilitate overwintering of *Culex* species. Use of underground tunnels associated with CSS as hibernacula by *Culex* species has been identified intermittently since 2003 (J. Kerce, personal communication). The potential thus exists for trans-seasonal maintenance of WNv due to the overwintering of *Culex* spp. in CSS. (Bugbee and Forte 2004, Nasci et al 2001).

A study currently being undertaken by a graduate student from North Carolina State University with the cooperation of Clarke Mosquito Control and the city of Atlanta has the following objectives: 1) to determine the seasonal dynamics of mosquito production associated with CSS and CSO, 2) to look at the potential mitigation of mosquito production in Atlanta CSS utilizing a granular formulation of the bacteria *Bacillus sphaericus*, 3) to study the seasonal host-feeding habits of *Culex* species within and adjacent to CSS, 4) to collect overwintering *Culex* spp. in CSS infrastructure and adjacent natural and man-made sites to test for West Nile virus, and 5) to quantify the potential influence of these epidemiological parameters on public health in adjacent communities.

Study #3

Historical and current data suggests a relationship exists between the presence of large numbers of mosquitoes breeding in manmade environments in urban settings, such as CSS and constructed wetlands, and arboviruses. For example, during the St Louis Encephalitis (SLEV) outbreak in Houston, Texas in 1980, extremely large numbers of *Cx. quinquefasciatus* were found in association with the city's storm sewer system (Monath and Tsai 1987). However, it was not determined if mosquitoes from these sites were transmitting the virus.

Research to determine dispersal and flight range of mosquitoes from CSS has been proposed and is waiting funding. The long-range goal of this research is to better elucidate the ecology of mosquito vectors in urban areas in general. Achieving this goal will lead to improved methods of risk evaluation, disease modeling, surveillance, and long term control and prevention strategies.

CONCLUSION

Little is known about the relationship between CSS-production of *Cx. quinquefasciatus* and WNv found in residential areas around these CSS. In addition, the ability to control mosquito populations in these areas is limited due to access and other issues, including acceptability of various types of control and funding. A scientific understanding of the role of CSS-supported mosquito populations to the epidemiology of WNv in the city of Atlanta will provide, amongst other things, the basis for a science-based Integrated Pest Management approach, as well as establish a reasoned approach to watershed systems with far reaching consequences beyond the presence of mosquitoes. A greater understanding of the impact of these combined sewer systems is required to minimize anthropogenic impacts and to begin to provide a better plan for vector control with the goal of reducing human risk of WNv in the area.

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